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[The following are translations of selected articles in the Russian-language monthly journal AVIATSIYA I KOSMONAVTIKA published in Moscow. Refer to the table of contents for a listing of any articles not translated.]

Long-Range Cruise Missiles Launched Successfully From Tu-160

94UM0004A Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 3, Mar 93 (signed to press 4 Mar 93) pp 4-7

[Article by Colonel S. Valchenko under the rubric "For High Combat Readiness": "Resurrection—*The Tu-160 is Part of the Russian Air Forces!*"]

[Text] *The crew of a Tu-160 supersonic missile aircraft launched a long-range cruise missile for the first time in the Russian Air Forces on 22 Oct 92.*

The crew was headed on this flight by Lieutenant-Colonel A. Zhikharev. The co-pilot was Lieutenant-Colonel N. Moiseyenko, and the navigators were Lieutenant-Colonel A. Gavrilov (aerial navigation, weaponry) and Lieutenant-Colonel A. Pakulev (EW, communications). They are all top-rated specialists and masters of their trade. The commander has 400 hours of flying time, out of a total of 1,600, on the Tu-160. The operations of the air strike system on the route were monitored by the crews of a flying laboratory—an airborne command and telemetry station (KIP).

The Tu-160 went up from the base airfield at precisely the appointed time. Lieutenant-Colonel A. Zhikharev brought the aircraft out to the permitted launch zone. Having received the confirmation to release the cruise missile, the crew executed the launch and took a heading for the airfield.

The KIP aircraft tracked the missile, recording the parameters of its autonomous flight. The KIP transmitted that the target had been hit after the Tu-160 had landed!

The first to congratulate the fliers on their success was Long-Range Aviation [DA] Chief Navigator Major-General V. Yegorov. Here is what he had to say about the event: "Russia needs not only means of defense that inspire respect, but also means of effective deterrence. They include the greatest achievement of domestic aviation thought—the Tu-160 aircraft system. The significance of a practical launch of a long-range cruise missile, made from the Tu-160 aircraft for the first time in the Russian Air Forces, is difficult to overestimate. The results of the intensive work to assimilate this most modern aircraft system have come to their result."

A day later Lieutenant-Colonel A. Malyshev and Major V. Adamov brought back an excellent grade from a flight for weapons delivery. Lieutenant-Colonels Zhikharev and Gavrilov were instructors this time.

The practical launches of low-altitude, long-range cruise missiles from the Tu-160, as was justly noted by the chief navigator of DA, crowned the intensive labor of the flight personnel and ground specialists. The course of combat training of the strategic flight crews was under the steadfast attention of the commander-in-chief of the Russian Air Forces for several months. They awaited information from each flight shift that took place here as paramount at the headquarters of long-range aviation. And here is why. It was namely at this airfield that the question was being resolved of whether the aviators of the Russian Air Forces would be able to master the most powerful modern-day aircraft system in the world—the Tu-160—in a short period of time.

The Tu-160 fourth-generation aircraft is a heavy, multimode and multipurpose missile-carrying bomber with a variable-geometry wing. It embodies the merits of the best domestic heavy aircraft. Modern aerodynamics, a high thrust-to-weight ratio and the ability to carry various types of weaponry have made it a weighty element in the aviation component of the domestic nuclear triad. The aggregate striking power of a single Tu-160 is commensurate with the striking power of two Tu-95MS aircraft or two squadrons of Tu-22M3 aircraft. A strike group of three or four such aircraft is able to make any aggressor nation listen to reason.

The list of measures and quantity of manpower and equipment to prepare the Tu-160 for a weapons-delivery sortie could be compared to the launch of a spacecraft. Imagine for a moment that the specialists at Plesetsk or Baykonur were to leave their prepared launch sites, select a new and unprepared location and launch a spacecraft from it in a month or two. Impossible? Well, the Russian aviators that had to master the Tu-160 were in roughly that same situation. And they came through with honor.

But how did that become possible all the same? Why did the Russian fliers have to master a most complex aircraft system in a crash course?

The first Tu-160 aircraft, which were an answer to the American B-1, began coming to the Air Forces for experimental operation as early as in 1987. The training of flight personnel for their planned assimilation began at the same time. By January of 1992 there was a fully combat-ready unit of these aircraft at Priluki in Ukraine. This was the Guards Poltava-Berlin Order of Lenin, Red Banner Air Regiment, which was the foundation of the striking power of Soviet strategic aviation. A breach soon appeared, however, in our overall "defensive shield." All of the latest aircraft were unilaterally declared to be the property of Ukraine. The personnel were "democratically" offered the chance to take the oath and remain at Priluki or to return to the Russian Air Forces. Many chose Russia.

What did Ukraine get as the result of this division? Nothing. Because all of the "privatized" Tu-160 aircraft were laid up immediately. There were none of the special fuels or spare parts. All of the plants that supplied constituent items remained outside of "independent country." No one ended up the winner from the resultant situation. Assertions were then heard in some places that Russia had been deprived of the Tu-160s, and would not soon be able to make up the loss.

The Russian aviators to whom it fell to prove the reverse had to overcome many difficulties. All of the ground-preparation physical plant of the bomber regiment—the simulators, missile preparation positions, specially equipped facilities—had been left at Priluki. There were not enough specialists. The technical crews were brought up to strength using personnel from the local regiment. It was not enough to retrain those people—their professional psychology had to be altered. Almost all of them, after all, had been servicing tanker aircraft, and could not conceive of the specific nature of service in a regiment of long-range bombers.

The flight personnel had their own concerns. When new aircraft were delivered from the plant, when the system of ground support was deployed and the engineering and

technical personnel were trained on them, an intolerable interruption in flying occurred among the pilots and navigators. They had to resurrect their skills. And that was all once again in a brief period of time.

But all of these are military difficulties. But add to them the social and domestic ones as well. The families of many of the fliers had remained in Ukraine, and they still have to travel there on leave. The apartments in the new garrison are still, as they say, only "a gleam." That is how they live. And all of that for the sake of resurrecting strategic aviation. For the sake of Russia.

The intensive process of assimilating the strategic supersonic missile aircraft is behind them today. The answer has been given—the Tu-160 is part of the Russian Air Forces!

And now we give the floor to those who were involved in this event, a truly historic one for the Russian Air Forces.

Lieutenant-Colonel V. Karpov, inspector-navigator of long-range aviation: "I was at that airfield along with senior inspector-pilot Lieutenant-Colonel A. Medvedev for three months. Everything took place before our eyes. First we made check flights in the new aircraft. Then we flew as instructors to "resurrect" the command personnel of the regiment. We studied special techniques on the ground with the pilots and navigators. The program to prepare for the practical launches was fulfilled entirely as a result. The flight personnel tried very hard, since the Tu-160 is the favorite aircraft of all. The piloting and navigational system has no analogue in our aviation. No aircraft can compare in thrust-to-weight ratio or aerodynamic properties. It was also highly regarded in the West. Our hero was named the Blackjack there—you won't encounter one better, they say.

"It is noteworthy that this powerful craft is in the sure hands of Russian fliers."

Lieutenant-Colonel S. Toporkov, senior engineer of the formation for missile weaponry: "I came here along with those who did not stay at Priluki. We had to get used to an airfield all over again, one that was not adapted for the operation of the Tu-160. Every technical crew at Priluki, by the way, had a shed on the hardstand. Here it was just an open field. All of that had to be built. There were not enough facilities to service the aircraft, or individual protective gear—respirators, special gloves, footgear. But people must be given their due: they tried without sparing themselves. Major A. Smyzhin made the first flight of the Tu-160 at this airfield. This was, so to speak, his second debut. He had been the first at Priluki. I would also like to note among the technical crews Captain G. Farkhutdinov, senior lieutenants V. Sapsay, K. Korepanov, N. Ivnitskiy, S. Stepanchenko and lieutenants A. Nikolayev, A. Ibrayev and O. Solyanik. They are by and large young fellows, but skilled and diligent."

V. Ryazanov, supervisor of the scientific crew of the airborne command and telemetry station: "The KIP aircraft is a scientific subunit of the Flight Test Institute imeni M.M. Gromov. We were brought in as part of the scientific support for the practical launches of the cruise missiles. The special gear installed on the Il-76 aircraft makes possible the comprehensive analysis of the operations of the strike system and the monitoring of the independent flight of the cruise missile for all the principal parameters. The KIP can issue a command to self-destruct the missile in the event it strays off course. But we did not have to issue that command during the practical launches from the Tu-160. The missiles followed their routings precisely, and hit the training targets. I would like to make note of the work of our specialists—test pilot G. Stadnik, navigator A. Kurmangleyev and lead engineers for flight testing N. Yefremov, F. Khaziyev, V. Ozeritskiy and V. Usik..."

In place of an afterword: *One of the many newspaper features on the Tu-160 reported that "Series output could be curtailed." "If that happens," wrote the journalist, "then the priceless experience gained in the process of creating the heavy bomber would be lost, and a breach that will be difficult to close will appear in the aerial strategic shield of our Homeland..."*

What can be added to that? It only remains to share this anxiety. Would a decision that would lead to unilateral disarmament, to the loss of defensive scientific and technical potential, really be sensible? It would set us back 10—15 years in a technological regard. The answer would seem to be obvious. Russia needs strong wings—such as those of the Tu-160 aircraft.

More Intelligent Thrust to Accident Prevention Proposed

94UM0004B Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 3, Mar 93 (signed to press 4 Mar 93) pp 8-9

[Article by Colonel-General Ye. Rusanov, chief of the Aviation Flight Safety Service [SBP] of the Armed Forces of the Russian Federation, under the rubric "Flight Safety: Experience, Analysis, Problems": "Thousands of Dangerous Situations..."]

[Text] *...those being the thousands of dangerous situations that arise owing to omissions and oversights by many officials that are compensated for every year by military pilots, risking their health and sometimes their lives.*

The conditions for maintaining the level of flight safety that had been attained (not to mention further improvements in it) have changed for the worse in recent years. The extent of the hazardousness of factors affecting the failure-free operation of all components of the "pilot—aircraft—environment" system has increased first and foremost, and flying time has decreased in general and for each pilot or crew in particular. The lack of the necessary quantity of fuels and lubricants and training ordnance, along with the difficulties of infrastructure and amenities for the personnel of aviation and supporting units caused by the cutbacks and relocations of the troops, is having an acute impact. All of this is having a negative impact on morale and the psychological state of the fliers, and is reducing the motivation to continue both flight work and military service as a result.

It is nonetheless namely in this difficult climate that it is essential not only to pursue, but even to intensify the work to prevent flight accidents, since each of them causes great harm to our aviation and the army as a whole.

It would obviously not be sensible, given the realities of the current moment—where instances of failure to observe the

requirements not only of official documents, but even fundamental ones (decrees, edicts, resolutions), are becoming far from isolated—to be limited just to the customary directive and disciplinary methods for ensuring flight safety.

Yes, the aviation documents are strict. One difficulty of the current period is the fact that most of the basic manuals and guides regulating flight work, whose unconditional fulfillment by every aviation specialist—first and foremost the pilot himself—is required, unfortunately assume his complete provision with everything that could have an impact on flight safety. That is far from always possible everywhere or for everyone today, however. And closing our eyes to these gaps between, figuratively speaking, yesterday's and today's flight organization is not the best method of action for aviation commanders of all ranks or for the officials of the SBP. Under these conditions, it would be expedient, while preserving the established principle of ensuring flight safety "from the top down" (High Command—larger formations and units—air unit—pilot), also to take into account the degree of motivation to prevent accidents "the other way"—"from the bottom up" (that is, to start right with the pilot).

The pilot was considered to be the **object of exhortation**, monitoring and, of course, sanctions under the command-administrative system for his failure to observe a host of flight-safety requirements from officials at all levels when preventive measures were organized to avoid accidents. It came to pass that he, while personally risking, at a minimum, his flight and service career and, frequently, the state of his health and sometimes even his life in a flight accident, seemingly had considerably less of a vested interest in the safety of his flights than a host of superior officers!

When preventive work is optimized relying on the predominant role of the **personality of the pilot**, for whom all the higher structures should be working, we obtain a powerful supplement in the form of the organizational energy of thousands of pilots (or members of flight crews) to the efforts of dozens of SBP specialists. It is no secret that it is namely the pilots who in practice prevent thousands of dangerous situations arising from the omissions and oversights of officials in various fields every year. But there are reserves here as well, since almost every one of the crashes and accidents that occurs over the course of a year could have been prevented or, at least, had a less grave outcome with timely and correct actions (after the dangerous situation arose) by the crew. The unsatisfactory level of training of the flight personnel in practical prevention of the accidents that are most typical of their branch of aviation and type of airframe, however, leads to the systematic repetition of one and the same accident and crash situations arising out of objective or subjective unfavorable factors that are exhaustively studied by the SBP specialists, but prove each time to be new and unexpected for the next crew to get into the difficult situation.

That is just what happened when an Mi-8 helicopter hit a mountain slope hidden by cloud cover and crashed while transporting refugees from the Transcaucasus in July of last year. The air-traffic control bodies had not satisfactorily analyzed the conditions for flying over this mountain pass, while the crew, going up into mountains with cloud cover, was not able to assess the danger of that factor under the concrete conditions of the flight. Three crew members and ten passengers were killed as a result.

Another crash, even more grave in its consequences, occurred a month later in the same area when the same mission was being carried out. The crew of an An-12 cut short their takeoff run virtually without separating. The aircraft rolled over the end of the runway, hit some obstacles, was smashed and burned. Thirty-six people died. Doubts of the successful outcome of the flight had arisen among the pilots owing to the high air temperature, the maximum loading of the aircraft and the specific features of the shape of the runway. All of these dangerous factors had not been taken into account by either the crew or the airfield dispatcher.

Could the crews have averted just these outcomes in these specific situations? Investigation indisputably demonstrated that such a possibility was virtually guaranteed—the crews were entirely able to avoid creating a situation fatal for each of them and then, when it had arisen all the same, could have countered its unfavorable development and ended the flight safely even though it had begun to be aggravated. It is namely in these two directions—**not creating dangerous situations, and if they arise anyway, preventing their aggravation and reducing the gravity of the outcome by the most effective means**—that should guide the training of flight personnel.

The seeming simplicity of such a concept for practical preventive work, however, requires sound analytical and methodological work in each branch of military aviation to select and quantify the typical (repeating) special situations, to practice techniques for averting them, and then to localize each of them and ultimately devise and maintain the skills for the whole range of techniques developed. It can be accomplished most effectively at the centers for the combat application of aviation, in close interaction with the specialists of the Combat Training Directorate and the Flight Safety Service.

In the realization of the proposed model for preventive work, each pilot or crew will be able to select, regardless of directives from above, the most expedient positions from among the set of techniques for repetition namely those elements of the flight mission, in the fulfillment of which he senses the predominant danger, and to practice them in class, on a simulator or on a computer when preparing for a specific flight.

The activity to ensure flight safety by the higher commands and inspectorates will undoubtedly require optimization under contemporary conditions. Each of them should strive to create for their subordinate levels (or interacting levels) the most favorable working conditions to maintain the required level of flight safety in a contemporary setting. This is already being realized through the cutbacks in the previously widespread host of inspectorates and checks, performance ratings and other measures of an administrative type, and the redistribution of efforts in the direction of performing methodological measures and assisting in each area. The basic principle of the structures controlling the activity of the air regiment should be to provide its command personnel with the most favorable climate for planning, organizing and conducting flights.

The urgent task of all the services participating in flight training should be considered to be the elimination of dangerous factors under their control that a the cause of the appearance and aggravation of dangerous situations. Thus, for example, the investigation of the most severe flight accident of last year—the crash of a transport aircraft landing with passengers on board at night in minimal weather conditions at a back-up airfield that had not been assimilated before—first placed the focus on crew error in the performance of the pre-landing maneuver. Detailed study of the circumstances of this tragedy, however, showed that the actions of the crew only crowned a situation that had been conditioned by violations, omissions and blunders by a whole series of officials who had given the assignment and prepared the crew, made the decisions for takeoff and rerouting, were responsible for the lighting and electronic equipment of the airfield, analyzed the weather etc. If any one of these had made the correct decision and carried it out, the crash situation may not have arisen.

As for scientific developments in flight safety, it would be expedient to concentrate efforts today on the "applied" questions—maintaining the level of proficiency of pilots under conditions of irregular flights, and substantiating measures to avert the most serious flight accidents.

It is essential to emphasize in conclusion the importance of uniting the efforts of specialists from all agencies in the performance of everyday work to prevent accidents in aviation under contemporary conditions. The expensive experience that has been acquired in the investigation of flight accidents should be utilized with the maximum possible promptness and completeness in the aviation of the armed forces of the Russian Federation. A closed-doors mentality is impermissible here, since it only reinforces the method of trial and error (such as the fact, for example, that analogous accidents happened after the crash of the An-12 on civil aircraft in Vladivostok and Tbilisi). This pertains entirely to the intelligent utilization of foreign experience in flight safety.

New Engine Diagnostics System Uses 'Black Box' to Track Parameters

94UM0004C Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 3, Mar 93 (signed to press 4 Mar 93) pp 10-11

[Article by Candidate of Technical Sciences Lieutenant-Colonel G. German, Captain V. Velenteyenko, chief of a routine TECh [technical-maintenance unit] operations group of an air regiment, and Candidate of Technical Sciences Colonel (Reserve) A. Kaulis under the rubric "For IAS Specialists": "BUR in the Service of Diagnostics"]

[Text] **The design of modern aircraft engines (AD) is improved every year, and the amount of work to service them and the testing and check-out gear (KPA) employed grow more complex as well. But the number of specialists taking part in performing that work, as in the IAS [aviation engineering service] as a whole, is decreasing. How can the efficiency of monitoring the reliability of aircraft engines be increased under those conditions?**

A group of staff members at the ERAT NII [Scientific-Research Institute] of the Air Forces took up the solution of the problem. It is well known that improvements in operational monitoring of the parameters of aircraft engines occur in competition between two directions in their development—the creation of on-board (BASK) and ground (NASK) automated systems. Each of these has its own advantages and disadvantages. The advantages of BASK include high mobility, autonomous operation and promptness in application. Being located on the aircraft, however, these systems are limited in the amount of information they can monitor (both in the range of parameters and in the frequency of checking them) and have a quite rigid operating program that does not, as a rule keep pace with changes in the equipment of constantly upgraded aircraft.

NASK are by and large devoid of these shortcomings, but appreciably reduce the mobility of the maintenance equipment and its autonomy, as well as requiring more—and more highly skilled—servicing personnel. Moreover, by duplicating a number of on-board systems they markedly increase the cost of the aviation system.

Taking this into account, the attention of specialists turned to the well-known "black box"—an on-board recording device (BUR) that is used in contemporary aircraft and helicopters to record the parameters of the flight and the principal aircraft systems (including the engines). It is highly reliable, and has the ability to preserve information on several hours of aircraft systems operation that is acceptable for diagnostics through the measurement of deviations in the parameters. This information is used even today in the interests of determining the operability of the aircraft engines when preparing it for a repeat sortie. The use of BURs as a means of ground monitoring of the ADs, however, is hindered for two reasons. The first is that a BUR, as a consequence of its principal purpose, has a strictly limited range of engine parameters it monitors—the engines get from 7 to 15 percent of the information recording volume. The second reason is caused by its discrete nature; the values of each parameter are recorded at strictly defined time intervals that are typified by the frequency of polling, that is, the quantity of values recorded per unit time (per second, for example). The polling frequency of aircraft engine parameters used in series-produced BURs does not make it possible to obtain reliable information on the most diagnostically informative modes of its operation—transitional modes (for instance, the pickup or shedding of RPM) that last for only a few seconds in all.

The efforts of the NII specialists V. Dolgopolov, K. Suponko, A. Poluektov, V. Semenin and L. Yevlakhov were aimed at solving just these problems. The key here was the fact that during the process of ground check-out of the engine parameters, most of the remaining aircraft systems—information on which is fed to the BUR—are not being monitored and, consequently, the recording channels for their parameters are temporarily not in use. This in fact determined the later actions of the innovators—to create a relatively simple and small piece of ground equipment that would make it possible to switch over the "idle" channels to the engine. The amount of information received from it increased by 10—12 times, thanks to the increased polling frequency of the standard parameters and the opportunity to monitor other parameters of the ADs through the installation of additional sensors on board the aircraft.

The gear, in interaction with the BUR units and the AL-31F aircraft engine electrical regulator, constitutes the system of ground monitoring of aircraft and engine parameters (SNK-SD). A diagram is presented in Fig. 1.

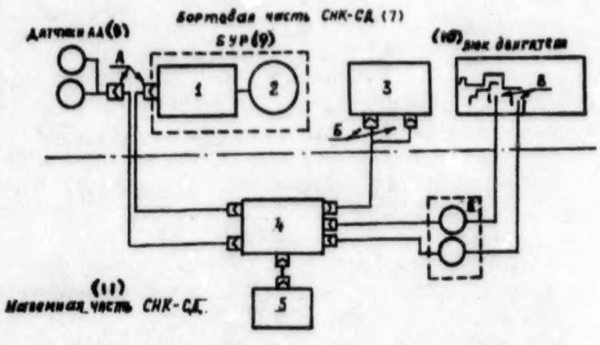

Fig. 1. Diagram of the SNK-SD ground monitoring system

Key:
7. on-board portion of SNK-SD
8. AD sensors
9. BUR
10. engine hatch
11. ground portion of SNK-SD

The on-board part of the system consists of a unit for formulating and coding the information of the BUR (1), the BUR information storage (2) and the AD electronic regulator (3). It is intended for the receipt of primary information on the parameters that are usually recorded by the on-board equipment and the parameters—new in relation to them—of the electronic engine regulator, electrical feed of the SNK-SD from on-board sources, conversion of analog information to digital and storage of all of the data obtained with the aid of the SNK-SD in the BUR storage unit.

The ground portion of the system includes a switching unit (4), a control panel (5), and an arm with additional sensors (6) intended for the formation of high-polling (frequency of 12—16 Hz) channels for the recording of parameters, varying their selection and monitoring their progression to the BUR storage unit in real time and the receipt of primary information on the engine parameters being measured by the additional sensors.

The locations for connecting the SNK-SD on the aircraft are: the BUR—the input of the standard monitored parameters to the unit for the formulation and coding of the information (pos. A); the electronic AD regulator—the control plugs of the regulator used in servicing to hook up the KPA (pos. B); and, the control points for the measurement of additional parameters of the engine via the installation of sensors at them from the SNK-SD kit (pos. C).

The information from the on-board sensors, electronic engine regulator and the sensors from the SNK-SD kit goes to the switching unit, where it is distributed in accordance with the settings of the switches on the control panel among the channels with a high polling frequency and transmitted to the input of the BUR formulation and coding unit, where the analog signals are converted to digital. The information is copied from the storage unit to standard media (BK-2 magnetic-tape cassettes) after the engine is disconnected, for subsequent processing in Luch or Mayak type ground processing devices (NUO) using specially developed control programs. An external view of the ground units of the system and the places to connect them to the aircraft is shown in Fig. 2.

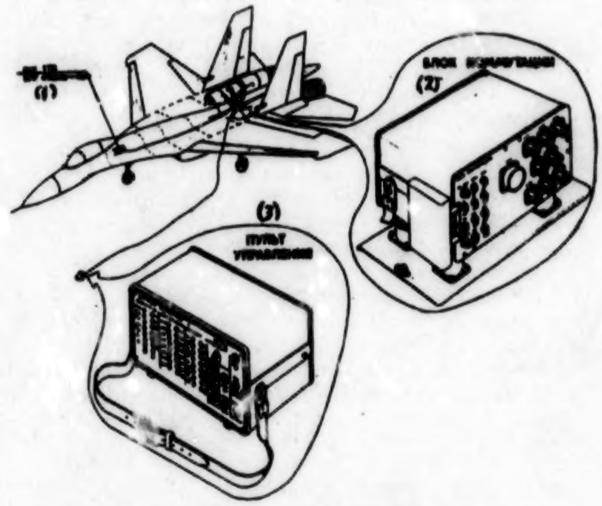

Fig. 2. Composition of the SNK-SD system

Key:
1. 1TB unit/"Tester-UZ" BUR
2. switching unit
3. control panel

The SNK-SD combines the advantages of both directions in the development of engine monitoring equipment, and makes it possible to avoid the appearance of cumbersome and expensive KPA in servicing that requires an increase in the number of organic service personnel and increases labor expenditures for operation. It has a high degree of standardization, since one and the same ground unit of this system, differing only in the soldering of the electrical connections, is needed to monitor different aircraft that have the same type of BUR. The SNK-SD, utilizing standard ground processing devices, also provides for a uniform ideology for monitoring the status of the aircraft hardware. Since the final information in the BUR buffer is in digital form, the use of personal computers to process it in real time is possible in the future, thereby eliminating the principal inconvenience of the "black box"—the lack of results at the time of monitoring, and the need for subsequent processing of the data.

Experimental check-out of the SNK-SD in several air units showed that this system increases the efficiency of monitoring, both when it is used in the squadron in the process of making flights or in the performance of technical maintenance operations requiring the testing of the AD, as well as in TECh units in routine maintenance or repair operations. The following variations for its utilization were the most expedient:

—operational monitoring, when performing flights, to look for failures that arose in a prior sortie, as well as to evaluate the technical state of the engines under the conditions of an air squadron without activating the standard KPA. Only the switching unit and control panel are used from the ground portion of the SNK-SD therein. The additional sensors are installed only if necessary and, as a rule, no more than two. The time to install and connect the SNK-SD is less than ten minutes;

—the deeper monitoring of the technical state of the engines in the process of performing routine maintenance operations, as well as operations to prolong the service life of the engines and find and eliminate failures. The sensors from the SNK-SD kit are installed during the ground testing. The time expenditures to install the SNK-SD on board the aircraft are compensated for by the substantial increase in the extent of the monitoring and, in a case of finding and eliminating failures in the ADs, by the determination of the causes for the disruption in operability with precision down to the replaceable part, unit or assembly.

The operational check-out of the developed system revealed yet another important merit—documentation of the results of the monitoring, which none of the ground engine monitoring panels traditionally employed as KPA possesses.

Here is an example of the use of the SNK-SD. The afterburner mode of operation of one of the engines did not come on in advanced aerobatic maneuvers by an Su-27 aircraft, as a result of which the pilot was forced to curtail the performance of the assignment. Check-outs performed on the ground of the stability of these modes using the standard KPA brought no clarity—the afterburner chamber ignited in all of the ground tests, which gave grounds to doubt the reliability of the primary information on the failure of the afterburner in flight. Then the SNK-SD system was connected to the aircraft in the variation of deeper monitoring of the technical state of the engine, with five additional sensors installed on board to check the fuel pressure in the automatic engine control system (in the area pertaining to the feed of fuel to the afterburner chamber). The specialists were convinced, after a ten-minute testing of the engine with the afterburners turned on four times and decoding of the results obtained on a LUCh type NUO, that the fuel pressure in one of the assemblies of the afterburner loop that supported the ignition of the afterburner chamber was below the stipulated limit. This did not lead to engine failure when the afterburners were turned on under ground conditions, but under the conditions of the evolution of the aircraft when performing advanced aerobatic maneuvers it was the reason for the failure of the afterburner to come on. The "heart" of the Su-27 operated reliably in flight after the replacement of the assembly.

The experience in the use of the system shows convincingly that the SNK-SD makes it possible, during one period of engine testing, to establish the cause of a disruption in its operability and make decisions regarding ways of eliminating the failure and its further operation.

The preparation and production of a series-produced lot of these systems for conducting tests in the field is currently underway. Techniques are being developed to utilize the SNK-SD in order to support the servicing of aircraft engines according to their technical state. One would like to believe that all of this will help the specialists of the IAS make a worthy contribution to increasing the safety of flights and maintaining a high level of combat readiness of the aircraft hardware.

Russian Flight-Testing Procedures, Duration Compared to American

94UM0004D Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 3, Mar 93 (signed to press 4 Mar 93) pp 16-19

[Article by Honored Test Pilot of the USSR Major-General of Aviation (Retired) A. Maucharov and Candidate of Technical Sciences A. Lapin under the rubric "The Floor to the Test Pilots": "A Good Aircraft Means a Well-Tested One"]

[Text] The flight testing of the latest combat aircraft is one of the most labor-intensive and crucial stages in the overall process of realizing the program of equipping the Air Forces and naval aviation of the Russian Federation with them. It is namely at that stage, after all, that an objective evaluation is made of the new ideas and engineering solutions made inherent by the designers in their aircraft, and the fine tuning of the whole aircraft system is performed. The suitability of a prototype for the performance of the combat tasks that define its purpose is evaluated, and recommendations on the possibility of putting the aircraft system into service and beginning series production are made, only according to the results of full-scale ground and flight check-out and testing under conditions that approximate operational ones. Flight testing itself, including the preparations for it, makes up more than half of the amount and duration of the time and financial resources allocated for the creation of an aircraft system.

A good aircraft means a well-tested one. This exceedingly topical subject has already been raised in the article by test pilot A. Akimenkov, "What Keeps Our Aircraft From Being Better" (AVIATSIYA I KOSMONAVTIKA No. 7, 1990). The author invited interested readers to discuss it. We would thus like to dwell, relying on many years of personal experience in participating in the testing and refinement of new aircraft systems, on the principal shortcomings that are characteristic of the process of creating and adopting aircraft hardware in the field, and try to determine ways of eliminating them.

We would note, first and foremost, that the amount and duration of flight testing and its quality and effectiveness depend on many factors, some of which are fundamental. We will thus begin the process with an analysis of the process of formulating the preliminary specifications (TTZ). These are traditionally prepared on the basis of the results of scientific research and experimental inquiry that are performed at the corresponding institutions of the customer and the principal executor, a comprehensive and objective analysis of the conceptual framework of the combat aircraft from the standpoint of its feasibility, the effective utilization of world scientific and technical achievements and actual capabilities for the creation of the new aircraft system with the assigned characteristics within the stipulated time frame.

All of the enumerated conditions are unfortunately far from fulfilled in domestic practice. And the point is not, as Akimenkov asserts, that the lead executor taking part in the formulation of the conceptual framework of a combat aircraft system supposedly "possesses every reason both to force his point of view onto the problem and to defend his own interests first and foremost," or even that "by the moment of write-up of the TTZ the final decision, as a rule, has been made." These assertions do not conform to reality.

The chief reason, in our opinion, is the fact that the realization of the TTZ in experimental design is not supported by the requisite scientific, engineering and production potential in industry; the full set of equipment and assemblies for the aircraft system reaches flight testing, as a rule, without proper autonomous and comprehensive working out owing to the restricted operating capabilities of the test-bench and modeling bases, means of preliminary assessment of the operability of aircraft systems in the course of physical testing (using flying laboratories and models and flight-modeling systems) and other reasons that are sometimes of a purely organizational nature.

The results of the fulfillment of the comprehensive program of testing of an aircraft system depend, to no small extent, on the technology for performing the flight testing that was formulated at the stage of preliminary design engineering of the new aircraft, the completeness of the implementation of measures within the framework of preparing the airfield technical gear of the test bases, the test-track equipment and the flight-control and target-guidance systems, the degree of simulation of hypothetical operation, the quality of the target equipment on the test range etc. The arrival of the prototypes for the performance of ground and flight testing according to plan is also an exceedingly material factor.

The resolution of all of these issues is largely conditioned by the organizational structure of the testing process—the principles for its planning, control and monitoring, the forms of interaction between the general customer and the principal executor and between military scientific institutions and organizations within those agencies, the clear-cut division of responsibilities (including financial) for the quality and deadlines for support and the performance of concrete types of ground and flight operations.

We cite as confirmation summary indicators of the flight testing (its overall duration, the number of flights within a fixed calendar period, the quantity and rate of deliveries of prototypes for testing) of the Su-24, MiG-25, MiG-23, MiG-31 domestic combat aircraft and the analogous American F-111, F-15C/D, F-14 and F-16. We will moreover proceed from the fact that we, as well as our colleagues across the ocean, adhere to the following conceptual model for the performance of flight testing: the realization of a comprehensive program should be fit into a stipulated time period, with the achievement of more complete conformity of the characteristics of the aircraft prototype to the requirements of the TTZ, and the expenditures should not exceed the amount of financing allocated.

The duration of the testing of domestic prototypes of aircraft, with virtually the identical number of aircraft (14) submitted for flight and ground operations, proved to be almost twice that of the foreign ones (6 and 3.5 years respectively). This is despite the fact that flight programs in the United States exceed our analogous ones by 70—80 percent, since the Americans conduct testing across a broader range of conditions for the combat application of the aircraft (this pertains to the target and jamming environments on the test ranges, and climate and other conditions). Their program moreover includes all the types of field (operational) testing necessary to resolve the the issue of putting the prototype into service.

The markedly longer period for the testing of domestic aircraft systems compared to the United States is connected with the low rate of test flights (350 and 850 a year respectively); the average annual flying time of our experimental aircraft is thus 2.5 times less than the American ones.

Such a large difference in the flight utilization of the aircraft being tested is in this case the consequence of a number of reasons:

—first, the low level of finishing of the individual constituent elements that are installed in domestic experimental aircraft, and the incompleteness of equipment ready for operation in the prototypes being tested;

—second, the greater losses of flight time caused, in turn, by the necessity of eliminating design and production shortcomings and defects that are revealed and the performance of finishing and reconditioning work, as well as the imposition of a number of restrictions for weather conditions and bans on flights;

—third, the insufficiently broad scope of the concurrent testing and refinement of experimental prototypes of scientific-research and experimental work on test benches, modeling systems and flying laboratories;

—fourth, the poor incorporation into flight-test practice of automated systems for the processing and analysis of flight information in real time, as well as the control of the flight experiment from a joint command post.

More than 70 percent of the calendar year here, all in all, is not spent for conducting test flights. Roughly half of them (by and large in the initial stages) moreover do not work through their flight assignments fully for various reasons (poor reliability of the physical equipment, prevailing test conditions etc.). This naturally requires that they be repeated, leading to a significant increase in the time and material expenditures relegated for the realization of the whole program.

The rate of delivery of aircraft prototypes is an extremely important factor affecting the duration of aircraft testing. A procedure has been established in the United States, for example, under which all prototypes arrive for testing by and large within the first two years of its start. A broad range of work to finish up and refine constituent elements and the aircraft system as a whole is thus ensured thereby. The principal delivery of aircraft here, on the contrary, is made during the second half of the testing period, which leads to the inefficient utilization of the inventory and, as a result, to poor results in the realization of the overall program.

The average statistical data cited pertain chiefly to fourth-generation fighters whose testing was conducted in the 1970s. Let us now compare the testing of the latest F-15E and Su-27 fighters.

The characteristic features of the F-15E that represent a profound modification of the F-15C/D aircraft are the efficient utilization of organic systems of on-board equipment and weaponry that have acquitted themselves well; their modification and modernization in accordance with the high requirements posed for tactical and combat performance characteristics of the aircraft system, reliability and operational service life; and, the limited incorporation of fundamentally new engineering that nonetheless ensures the fulfillment of the requirements posed for the aircraft prototype as a whole in the TTZ.

The program of creating a new combat fighter and equipping it for the Air Force, in accordance with the practice that has taken shape in the United States over the last decade, was entrusted to a supervisor who possessed broad authority and the corresponding staff apparatus, including a joint testing team. The composition of that team included representatives of the testing and operational subunits of the Air Force and the developer firms.

The testing was conducted according to uniform plans, programs and techniques for flight and ground operations with overall technical and economic support. The course of the operations and the results of testing were moreover under the constant observation and monitoring of the customer from the very start.

The composite schedule for the flight testing of the F-15E envisaged gradually bringing its individual constituent elements, and the aircraft as a whole, to the assigned parameters. The comprehensive plan encompassed an eight-year period, the first half of which (from 1983 through 1986) was devoted to conducting ground and flight operations before the experimental prototypes arrived for flight testing. The power plant, external fuel tanks, on-board radar set, digital flight control system etc. were all finished up during that time.

The whole program, proceeding from dedicated tasks, was subdivided into stages. Responsibility was divided in clear-cut fashion between the customer and the principal developer firm in each of the stages (depending on the content of the operations, the tasks that faced the testing team and specific organizational and departmental features), both on questions of both logistical and metrological support and in the performance of concrete experimental research. Questions of a financial and economic nature were comprehensively discussed therein.

The dedicated planning of operations was furthermore oriented first and foremost toward the widespread utilization of supermodern computers, providing for the processing and analysis of information in real time; toward modeling and the active management of the flight experiment in conjunction with the testing, which made it possible to obtain more complete data promptly; and, toward reducing risks when making the test flights. The program envisaged, aside form this, the separate finishing up and comprehensive check-out of the functionality of various systems of the aircraft system depending on the degree of their completion. It must be noted that the start of the next stage of the operations did not depend on the completion times of the prior one. Most of the types of testing were conducted in parallel, with a regard for the planned delivery of experimental aircraft and their constituent elements. This procedure made it possible to augment the quality of the constituent systems and the aircraft as a whole as early as during the course of the testing itself, in essence realizing the principle of "separate start—simultaneous finish."

The first experimental F-15E was officially turned over to the Air Force Flight Center for further testing just two months after making its first flight (it was required by the developer to clarify the allowable flight modes). The preliminary refinement testing of the principal constituent parts of the aircraft system was started at once at the flight center in accordance with the procedure stipulated by the U.S. Department of Defense. The autonomous and comprehensive verification of the functionality of the on-board electronics equipment, navigational and flight-control gear and weapons systems was accomplished chiefly using flying laboratories and specialized land bases. The effectiveness of the new combat aircraft as a whole was subsequently evaluated.

Field testing was conducted, in parallel with the pursuit of this set of measures, by the corresponding subunits of the Air Force under a so-called accelerated program—the combat qualities and operational suitability of the aircraft were comprehensively evaluated, overall guidelines for raising them were devised and the retraining of flight, engineering and technical personnel was conducted. The initial combat flight of the F-15E was thus provided for, as was planned, in the middle of 1990.

The performance of testing and refinement of the aircraft in such a short time (just four years) was largely facilitated by the observance of the optimal schedule for the delivery of experimental prototypes (three the first year, two the second and one the third) and the high rate of test flights (an average of ten per aircraft per month). The latter was achieved thanks to the efficient utilization of those airfield means that supported the possibility of the safe performance of flights virtually around the clock and under any weather conditions, the efficient management of the flight experiment from the ground, the processing and analysis of flight information in real time, the aerial refueling of the aircraft while performing individual tasks and a host of other measures, including some of an organizational-technical nature.

A large proportionate share of new structural and design ideas being embodied for the first time in the aerodynamic configuration, aircraft and weapons control systems, piloting and navigational equipment and on-board defensive systems was typical of the Su-27, as opposed to the F-15E. The testing of the Su-27 was conducted in accordance with the practices of many years that have taken shape here, which are based to a certain extent on prevailing statutes on the procedure for creating aircraft for military purposes. The fulfillment of the whole flight program, according to the results of which the decision was made to put the aircraft system into service, required about 13 (!) years—three times more than the Americans needed to test and adopt the F-15E. Such a prolonged period for the testing of the Su-27 by today's standards, aside from the other reasons indicated, was also connected with the poor flight return on the inventory of experimental aircraft (an average of four flights a month per aircraft).

The following should be kept in mind first and foremost in discussing the quality of the latest domestic combat aircraft. The look of the "standard" prototype, as well as recommendations pertaining to the procedure for putting it into service and submitting it for series production, was formulated according to the results of state testing—which does not include, as has already been emphasized, specific questions of field testing—in accordance with prevailing directive documents governing the course of testing and the adoption of combat aircraft into service. The final decision is made by the government, as represented by the Ministry of Defense. State interests, connected first and foremost with the plans for equipping the Air Forces (or Navy) with a combat aircraft system, the process of assimilating new production technologies and the functional aging of the aircraft, and conditioned in particular by the duration of the period of its creation, are entirely naturally taken into account therein. This, and a host of other aspects, could have a marked impact on the decision on the fate of a prototype even before its field testing, during which experience in the operation and combat application of the new aircraft is accumulated. The elimination of a number of shortcomings revealed in the course of that testing and the making of the necessary refinements to individual constituent parts of the aircraft system, under the procedure that exists here, are accomplished in the stage of series production, which slows the process of the entry of the new aircraft into service as a result.

In order for this not to happen, it is essential, in our opinion, to make a fundamental review ahead of time of the basic principles for the organization of operations in the creation of new combat aircraft with an orientation toward foreign experience (and first and foremost the United States). And we would like to single out the basic steps aimed at reducing the time frames and material expenditures in developing aviation hardware, as well as increasing its quality, in this regard.

The program for the creation and field adoption of combat aircraft, it seems to us, should be formulated and realized by a collegial body of the type of a state interagency council, headed by a supervisor of the program (named either by the general customer or the lead executor) who would exercise overall leadership and coordination of the work, answer for its performance in the required amount and be given the powers of a legal person to conclude contracts, expend financial resources, perform monitoring, employ sanctions etc.

A comprehensive program containing all the types of operations and the measures supporting them that are required for the scientific and technical substantiation of the TTZ and the performance of experimental design (design engineering, manufacture and testing), in an amount necessary for the evaluation of the constituent elements and the prototype as a whole in accordance with the preliminary specifications and the overall technical requirements of the Ministry of Defense, should be at the foundation of the activity of the council.

A joint testing team, composed of representatives of the corresponding organizations of the customer and the executor, should be one of the principal structural subdivisions of the council. Its direct participation in operations at all stages of the creation of an aircraft system—from the formulation of the TTZ right through to its adoption in line units—is mandatory therein.

The testing team should become the principal executor of the schedule of flight testing, which envisages a whole set of operations to refine the prototype as well as to perform field testing, according to a program whose fulfillment would make it possible to draw fully substantiated conclusions on the expediency of putting the aircraft into service and starting its series production.

The combat aircraft systems being created should complete joint (with the simultaneous participation of the executor and the customer) state testing (SGI). SGI, as compared to the flight-design or state testing that is currently conducted by these agencies independently, has the following advantages:

—the overall organization of the planning, management and monitoring of the preparation and performance of flight and ground operations would undoubtedly lead to a reduction in the expenditures of time and material resources, including through an increase in the rate and efficacy of test flights;

—the implementation of flexible planning would provide an opportunity to adjust the course of operations at various stages in the creation of an aircraft system, and to make timely decisions in that regard;

—uniform requirements would finally be devised for test-track complexes, target equipment at test ranges, the technological support of operations and the techniques for evaluating the characteristics of a prototype being tested;

—a real opportunity would appear for the clear-cut delimitation of functions and responsibility among all of the testing participants on questions of coordination, the efficient utilization of the testing physical plant, the experimental and auxiliary aircraft inventory, airfield and test-range equipment, systems of automated information processing and databases for the management of flight experiments that are common to all parties;

—a unification of the efforts of the highly skilled engineering and flight personnel of the testers and the military specialists in the operational subunits would certainly have an effect on raising the scientific and technical level of operations and the safety of the test flights, make it possible to resolve issues of the refinement of aircraft systems promptly and reduce to a minimum the expenditures of time and the consumption of material resources during the period of assimilation of series production of the new hardware and the start of its entry into service with line units;

—SGI, as opposed to the program of aircraft testing being practiced today in which the principle of its division according to departmental traits is inherent, would envisage its realization depending on the requirements for the stage-by-stage refinement of the constituent elements of the aircraft system;

—a separate stage of SGI could be allotted to measures (carried out with the aim of issuing findings for the production of a limited lot of the aircraft) whose results

would make it possible to determine the range of fulfillment of work operations projected earlier, and to evaluate in comprehensive fashion the conditions for its full-scale series production and successful assimilation in line units;

—special testing could also be performed (as one of the stages in the overall program), by decision of the program supervisor, to reveal the specific features of the field operation of the prototype and further improvements in its combat characteristics.

The following must also be noted: preliminary (plant) flight testing of the aircraft should be conducted—during the process of which it would be possible to evaluate the functionality of all systems and, if necessary, bring them to a level that reliably supports the safe performance of flights under SGI—before beginning SGI.

We would like to hope that these recommendations will be taken into account to a certain extent when the conceptual framework for a new statute on the creation of aircraft for military purposes is formulated under today's difficult economic conditions.

Zenit Reconnaissance Satellites Described

94UM0004E Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 3, Mar 93 (signed to press 4 Mar 93) pp 41-42

[Article by Yuriy Mikhaylovich Frumkin under the rubric "Without the 'Secret' Stamp": "The First Reconnaissance Satellite"]

[Text] *Up until recently, only specialists knew that some unannounced areas of work were envisaged, aside from the officially indicated ones, under the Kosmos program.*

One of them was the flights of the Zenit reconnaissance satellites. The work on those started in 1956, even before the launch of the first artificial Earth satellite in the world, with design-flight testing in 1962 and standard operations in 1963. These spacecraft (later modifications of them) served more than 20 years. One of their developers, Yuriy Mikhaylovich Frumkin, talks about the first Zenit.

Zenit is a heavy satellite intended for the performance of detailed photographic reconnaissance, equipped with three cameras with a lens focal length of F = one meter, one topographic camera (F = 0.2 meter) and radio reconnaissance gear.

The cameras were able to take pictures in a small series of frames and in long paths. The width of the photographed strip in satellite flight at an orbital altitude of H = 200 km [kilometers] was 180 km. Long-focus apparatus provided a resolution of the pictures equal to 10—12 meters, with the film supply sufficient for each spacecraft to take 1,500 frames.

The duration of the flight of the satellite, as confirmed by flight-design testing, was 8—12 days. The data obtained by the radio reconnaissance gear and telemetric information on the functioning of on-board systems, the power plant and structural elements was transmitted to Earth in radio communications sessions. The exposed film was returned to Earth together with the camera in a descent section (SA). Flight control was accomplished from the Control Center, with the participation of many ground and floating command and telemetry stations. Special ground services and aircraft also provided for the retrieval and appropriate delivery of the descent section that had landed.

The Zenit consists of two major sections—the instrument section (PO) and the SA. They are connected by a host of electrical, hydraulic and other types of communications. The descent section has a spherical shape with an outer covering of heat-protective coating. The strong and airtight metallic covering, with thermal protection applied to it, has three large hatches. The cover of one of them is jettisoned to open the parachutes as it reaches the ground. The other two are technological hatches, and provide for the installation of apparatus and equipment. The cover of one holds the portholes for the camera gear. The PO is made in the form of two conical fairings linked by a cylindrical insert. It is destroyed and burns up during passage through the atmosphere with the descent section returning from orbit. The configuration of the Zenit spacecraft and its mass, shape of the SA and basic functional systems in descent and landing are very close to those on the Vostok spacecraft. Despite their outward similarity (they were developed at roughly the same time), however, they have substantial differences (Fig. 1).

The specific nature of the tasks performed by the Zenit spacecraft presupposed fitting it with equipment based on new systems or considerably upgraded from the Vostok spacecraft. A new and quite complex project, requiring the resolution of a large number of problematical scientific and technical issues, was the special apparatus for photographic and radio reconnaissance. Apparatus was created with long-focus lenses. The specific features of its operation through multiple-pane portholes bearing internal pressure, the effects of weightlessness and other factors of flight, along with the small volume of the SA, were all taken into account therein. It was moreover necessary to ensure the high reliability of the apparatus, a broad range of adjustment characteristics, high resolution of the pictures obtained and precision in referencing them to the terrain.

Fundamental difficulties arose in the development of the system for orienting the spacecraft. It was necessary to have a virtually constant, precise three-axis orientation in the orbital system of coordinates in order to photograph the Earth's surface and obtain high-quality images, with one of those axes tracking the direction of the Earth in the orbital movement of the craft. The Zenit craft was able to realize this mode during flight testing for the first time in space science. The orientation system performed "rapid" programmed revolutions across a wide range of angles in order to expand the opportunities to obtain photographic information from the satellite, which made it possible to take pictures of areas located at a considerable distance from the flight path of the satellite. The orientation of the system was structured on the basis of fundamentally new optical and gyroscopic sensors, using logic blocks with a complex functional algorithm and multiple-nozzle control elements with economical modes for the consumption of the working medium (nitrogen). The principal units of this system were located in the instrument section, while the micromotors, tanks with the reserves of the working medium and optical sensors were mounted on its outer surface.

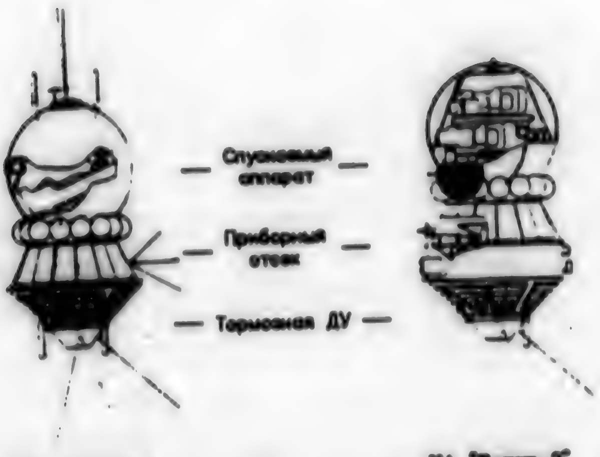

Fig. 1. Specific features of the structural configuration of the Zenit-2 spacecraft (as compared to the Vostok spacecraft)

1. Vostok spacecraft systems omitted from the Zenit-2 spacecraft:
   - 1.1. life-support system
   - 1.2. ejection seat, emergency reserve
   - 1.3. cosmonaut's panel
   - 1.4. means of manual control
   - 1.5. radio-telephone line
   - 1.6. command radio line
   - 1.7. television system
   - 1.8. control system
2. New systems on the Zenit-2 spacecraft:
   - 2.1. camera
   - 2.2. telephoto apparatus
   - 2.3. special radio gear
   - 2.4. special radio-telemetry system
   - 2.5. APO system
   - 2.6. Mayak radio system
   - 2.7. program radio line
   - 2.8. command computer
   - 2.9. control system
   - 2.10. control system for on-board systems
3. Systems developed on the basis of Vostok systems:
   - 3.1. thermal-regulation system
   - 3.2. descent section
   - 3.3. instrument section
   - 3.4. electric-power system
4. Systems borrowed with minimal changes:
   - 4.1. braking engine installation
   - 4.2. orbital radio-control system
   - 4.3. radio-telemetric systems
   - 4.4. "Signal" system
   - 4.5. landing system
   - 4.6. "Granit" program device
   - 4.7. direction-finding system

The control system for the on-board complex that provided the logic and electric-power control of all on-board apparatus was also qualitatively altered. The necessity of flexibility in the operational control of the photographic gear, its adjustment depending on the flight altitude, illumination of the Earth's surface, location, planned length of the picture track and much more required the creation of a complex program-logic device with a radiotechnical channel for the on-board program radio line. This was an innovation in the radiotechnical systems of spacecraft.

A number of difficult problems had to be solved by the developers of the system to maintain the thermal conditions of the satellite. The long-focus camera set the terms, since the quality of the pictures and their resolution were directly dependent on the range and rate of change of the temperature of the lens, the camera as a whole and the porthole. The maintenance of the temperature of the gas with a precision of about one degree posed a difficult engineering task in the face of the marked fluctuations in the values of the internal and external thermal fluxes.

The Zenit, as a secret device, had to meet special requirements, and systems were thus included in it for self-destruction in emergency situations (emergency detonation of the craft) and radio telemetry for the radio reconnaissance gear, as well as a means of protecting the information etc.

The design engineering of the Zenit spacecraft was performed on the basis of broad cooperation among scientific-research and experimental-design enterprises and major centers equipped with complex systems and devices for the experimental ground run-through of the satellite as a whole and its systems and assemblies, in close interaction with the customer, the Ministry of Defense, including using test-range services as well as the Kuybyshev OKB-1 [Experimental Design Bureau 1], to which all of the work on this type of spacecraft was transferred upon completion of the program of flight-design testing. The lead organization was Experimental-Design Bureau No. 1 (OKB-1), headed by S. Korolev.

Design research went on for two years (starting in 1956), and concluded with the selection of a configuration for the reconnaissance satellite and its principal flight and engineering characteristics, as well as the composition and operating principles of its on-board systems.

The return of the exposed film from orbit to Earth in a special capsule was envisaged therein. It was to have a relatively small mass, conical shape and be equipped, aside from the film cassettes, with the minimally necessary means to ensure the physical preservation of the film in flight in the atmosphere and in landing, as well as to find the landing location.

The second section of the satellite was designed to be larger. Its shape varied from cylindrical, with small conical or spherical ends, to a combination of complex shapes. This configuration was selected because an opportunity appeared, while reducing the dimensions and mass of the section to return to Earth and the required mass of the satellite as a whole, to increase the period of its active existence and the volume and quality of the information obtained. This was achieved through the installation of more advanced gear, an increase in the film supply and the working medium for the orientation system, and larger-capacity batteries for the electric-power system.

At roughly the same time, starting in 1958, the OKB-1 launched work on the creation of the Vostok mannedspacecraft. It was designed in two sections of roughly equal mass—an SA that was spherical in shape, and a PO whose outer contours were two cones, with articulated bases. The

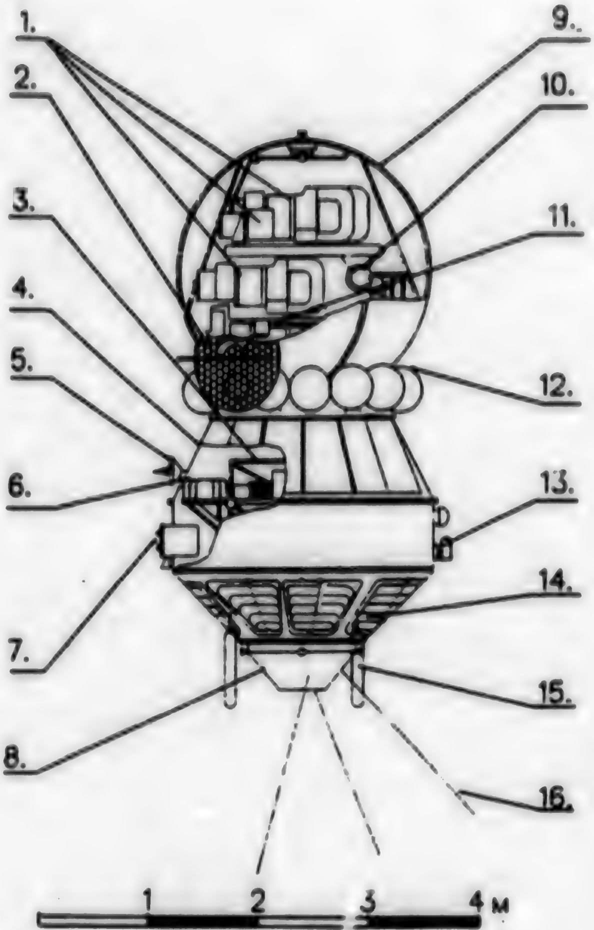

Fig. 2. Zenit-2 spacecraft

1. camera
2. antenna for special radio gear
3. electric-power system
4. instrument section
5. antenna for program radio line
6. apparatus of control system for electronic and other systems
7. infrared vertical reference
8. braking engine installation
9. descent section
10. explosive charge of the emergency detonation (destruct) system for the craft
11. control apparatus for landing, electronic and other systems
12. tanks for orientation system
13. sun orientation sensor
14. thermal-regulation system shutters
15. telemetric systems antenna
16. "Signal" system antennas

same configuration was adopted for the reconnaissance satellite under real "pressure" from S. Korolev.

This was not a simple solution, since the descent section was adapted to accommodate a person rather than the equipment of a reconnaissance satellite. The insistence of the Chief Designer and the inventiveness of the participants in the project nonetheless made it possible to solve this problem.

The Zenit (Fig. 2) as a result came to consist of an instrument section and a descent section with dimensions close to those of the Vostok spacecraft.

The PO accommodated units for the orientation system, the control of on-board systems, electric-power supply, thermostatic gear, radio systems and radio reconnaissance gear, among others. Its external surfaces had a host of antennas for the electronic gear, an optical sensor for orientation to the sun—used in one of the satellite turning modes before the issue of the braking command to descend from orbit—and an infrared vertical reference, which could also be used for orientation before descent from orbit. There were also rocket motors for orientation and tanks with the gas supply. The braking engine installation from the design bureau of A. Isayev and the radiator of the thermal-regulation system were also located in the lower section.

The descent section housed, aside from the camera, the landing system (a parachute system, automatic devices and sensors), means of electric-power supply, control of on-board systems, thermal regulation, radio stations to get a bearing on the SA, and a system for the autonomous recording of the readings of a number of sensors monitoring the process of the flight during the descent. A system for the emergency detonation of the craft was also installed in the SA (a charge, logic unit and sensors), which destroyed the contents of the descent section in the event emergency situations arose.

The transition to the new configuration, through an inconsiderable deviation from the configuration of the reconnaissance satellite optimized from a mass standpoint, made it possible to reduce the spending for its flight testing, since the important stages—deorbiting, descent and landing—had been worked out in testing of unmanned satellites and in the first manned flights of the Vostok spacecraft.

The flight and design testing confirmed the correctness of the decision made in 1958. This was one of many examples of the intuition and ability of the Chief Designer to evaluate problems broadly and comprehensively in the development of complex space projects. The results of the design engineering were formulated in the middle of 1961. The satellite had already been manufactured by this time, had completed a full cycle of ground run-through and was at the Baykonur cosmodrome. The flight and design testing was completed with the flight of a Zenit launched on 19 December 1963 under the name Kosmos-20.

Interkosmos-25 Satellite Pair Studies Ionosphere, Magnetosphere

94UM0004F Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 3, Mar 93 (signed to press 4 Mar 93) pp 45-46

[Article by Colonel V. Glebov under the rubric "Under the 'Interkosmos' Program": "A Plasma Experiment"]

[Text] The Interkosmos-25 (IK-25) satellite, with orbital parameters of apogee 3,083 km [kilometers], perigee 440 km and inclination 82.5°, was launched into orbit from Russia's Plesetsk cosmodrome using a Tsiklon launch vehicle on 18 December 1991. The mass of the spacecraft is 1,350 kg [kilograms], and the instruments and scientific gear 340 kg.

The dampening, orientation and stabilization system provides three-axis orientation in an orbital system of coordinates with a precision of 25° along the pitch axis and 10° on the roll and yaw axes.

The goal of the launch is to conduct an active plasma experiment (APEKS) for the scientists of various countries, in order to continue their basic study of the electrodynamic links of the ionosphere and the magnetosphere of Earth within the context of the overall Interkosmos program.

The magnetic storms and the attendant incursion into the planet's atmosphere of powerful flows of active electrons and ions leads to the formation of the polar lights, intensive bursts of radio noise and other phenomena that affect the biosphere and business and economic activity. The mechanism of the occurrence, relaxation in the atmosphere and generation of wave emissions of such electrons has been largely unclear up to now, and it is thus very important to conduct the study and model the processes with the injection of electron beams and plasma clusters into the ionosphere and magnetosphere of the Earth.

The possibility of creating a structureless antenna for long-range communications using plasma-stream systems of generators and emitting systems was verified in practice in the course of the scientific experiments.

Specialists and organizations from our country, Bulgaria, Hungary, Poland, Germany, Rumania, Czechoslovakia and Cuba took part in preparing the flight program and developing and manufacturing the on-board scientific instruments and ground systems.

The artificial injection of a beam of electrons and plasma from the satellite, with the synchronous measurement of the physical parameters of the environment, beam and fields generated using two separated spacecraft whose orbits make it possible to perform the measurements both at various distances (from 0.01 to 1,000—2,000 km) and at various (in relation to the areas of excitation of the environment and dissemination of the beam) zones of the ionosphere and magnetosphere, was at the foundation of the APEKS. The experiment envisaged study of the nature of the electrodynamic links of electromagnetic waves in the ionosphere and the magnetosphere, determination of the radio-emission properties of the modulated particles and plasma clusters, research of their dynamics in near-Earth plasma, modeling and initiation of the polar lights and radio emissions and research on the generation and propagation of waves at frequencies of 30 Hz—10 MHz and 0.1 HZ—10 KHz with the injection of modulated electron beams and plasma streams into the Earth's ionosphere and magnetosphere.

The scientific gear on the IK-25 includes two sets of instruments. The first has the active excitation apparatus—accelerators of electrons and plasma—and the second has diagnostic apparatus to study the propagation of electron energy (ions, flows of charged particles at the satellite), parameters of the plasma and low-frequency fluctuations in the magnetic field, as well as to measure the temperature of the plasma, the electrical and magnetic components of the low- and high-frequency electromagnetic emissions, the components of the quasi-permanent magnetic and electrical fields and spectral analysis of the electrical fields.

A subsatellite of 50 kg manufactured in Czechoslovakia was released from the IK-25 on 28 December 1991 in accordance with the flight program. It moved, without the use of corrective means, into an elliptical trajectory on the orbital plane. After separation the initial larger axis of the ellipse was about 450 meters, and the smaller about 220 meters. The distance between the satellite and the subsatellite could increase to five kilometers in view of the differing friction from the atmosphere. There is the possibility of keeping the subsatellite at a distance of dozens of meters to a hundred or more kilometers for a time sufficient to conduct the experiment using the corrective engine installation on the principal craft.

The subsatellite is equipped with apparatus that allows it to measure virtually the same set of physical values as the main satellite. The large spectrum of the same types of instruments of both satellites is supplemented by a system of technical support that includes a radiometer, a decoder of radio commands, interactive receivers, an orientation analyzer, a telemetric measurements unit and antenna-feeder devices.

The results of measurements are recorded on board the satellites with the aid of radio-telemetric systems and technical support systems. The information from the telemetric system is received on Earth by a command and telemetry complex on the territory of our country, supported by personnel from the space units; from the technical support system the information is received by domestic stations at Tarusa, Apatity, Troitsk and Medveziye Ozera as well as foreign stations as Panska Ves (Czechoslovakia), Neustrelitz (Germany), Havana (Cuba) and Stara Zagora (Bulgaria).

The flight and the operation of support and scientific instruments of the satellite are controlled from the Flight Control Center (TsUP) for spacecraft for national-economic and scientific purposes (Moscow), while the subsatellite is controlled by specialists and technical apparatus from the Panska Ves scientific station. The control of both satellites is coordinated by the main operations control group at the TsUP.

There are three to five communications sessions a day with the IK-25 satellite, in the course of which radio monitoring of the orbit, the transmission of command programs to the satellite and the downloading of telemetric and scientific information are accomplished. The on-board scientific apparatus is able to function in active and passive modes. The active mode is characterized by the injection of electron accelerators and plasma against a background of the operation of the remaining instruments in conjunction with the

radio-telemetric system in the information-recording mode. The observations of natural geophysical phenomena, in the absence of injections of electron beams and plasma streams, is an important part of the program, since the spatial and temporal dependencies in ionospheric-magnetospheric processes can be researched with the aid of the two separated satellites.

There is a regular exchange of data among the participants in the international space program for planning and operational control (current ballistic parameters, operating modes of the scientific apparatus, readiness for operation of the technical gear and reporting on the receipt of telemetric data, among others).

The APEKS project is being executed successfully.

Brief Survey of U.S. Imaging Reconnaissance Satellites

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[Article by Candidate of Technical Sciences S. Baskov, Candidate of Technical Sciences A. Dubovoy and A. Kachekan (experts from the Association of Practitioners of Space Science) under the rubric "Space Science Abroad": "Imaging Reconnaissance"]

[Text] The start of systematic imaging reconnaissance from space was laid down abroad with the launch of the Discoverer-13 spacecraft by the United States in 1960. It was to perform the tasks of detecting Soviet ICBMs, determining their quantities, ascertaining their characteristics and degree of vulnerability and mapping the territory of the USSR to determine target coordinates for American missiles.

Spacecraft of this type, depending on the degree of detail of the information obtained, were divided into survey reconnaissance (Samos-P) spacecraft, whose operation continued until 1972, and detail reconnaissance (Samos-M) craft, used for a longer period (up to 1977).

The first reconnaissance satellites were equipped with a camera. The exposed film was delivered to Earth in a special capsule that was jettisoned from the craft on an assigned stretch of its trajectory. A parachute system was actuated at a certain altitude, and the capsule descended to the ocean surface or was captured in the air by a C-130 aircraft.

It should be noted that only 26 of the 38 satellites in the Discoverer experimental series were put into orbit, and only half the capsules were recovered in the air or found in the water.

The United States launched the fourth-generation LASP (Low Altitude Surveillance Platform) spacecraft in 1971 to replace the functions of the Samos-P and Samos-M satellites. The set of photographic gear installed on board made it possible to obtain pictures of territories and objects with a resolution of 0.3—0.5 meters at the ground in detail mode and 2.5—3.5 meters in survey mode, with the transmission of information by radio channel. The satellite, which weighed about 14 tons, had fuel reserves that allowed it to change its operating orbital altitude from 150 to 230 kilometers, and to adjust it to provide for an active existence of six—eight months. The LASPs, like the imaging reconnaissance satellites of the prior generations, were launched periodically. A Samos-M detail photo-reconnaissance satellite was launched, as a rule, in the intervals between the end of the functioning of one craft and the launch of the next into orbit. There were 20 LASPs launched in all. The last launch (in April of 1986) was a failure—the launch vehicle blew up in flight.

All of the functions for the performance of imaging reconnaissance from space have been performed since that time by the fifth-generation KH-11 satellites, which were developed on a fundamentally new basis. The optical image is formed in them on the surface of the light-sensitive element of a CCD (charge-coupled device), which transforms light signals of varying intensity into electrical ones transmitted in digital form through a relay satellite to the ground station at Fort Belvoir (Virginia). This information then arrives in real time at the National Photographic Interpretation Center in Washington, part of the CIA.

The KH-11 satellites were launched by Titan-3D and Titan-34D launch vehicles into heliosynchronous orbits with parameters of inclination 96.2—97.8°, altitude at apogee 500—1,000 km and perigee 210—350 km, which allows the satellites to reach the areas being monitored at a time that is optimal in the lighting conditions of the Earth's surface.

The special gear of the KH-11 supports a resolution in the visible wavelength spectrum of 0.15—0.18 meters at the ground in a photographing strip of 2.8 x 2.8 km, and 0.5—1.7 meters in a strip of 90 x 120 km. These resolution values are potential, and they can be obtained only under ideal surveillance conditions (illumination of the Earth's surface of more than 950 W/m^2 and insignificant effects of atmospheric turbulence) and at absolute values of optical contrast. It was unsuited, at the same time, for the receipt of photographs at night. Cloud cover, which made the surveillance of the territory being monitored more difficult, was also an insurmountable obstacle for it.

One method of overcoming these drawbacks was tried out in August 1989, when the Columbia space shuttle placed in orbit a spacecraft with gear that functions in the visible and infrared bands.

This Advanced KH-11 satellite, which was erroneously called the KH-12, is able to obtain images in day or at night when there are cloud levels of up to four or five. It uses a telescope of the Hubble type with a main mirror diameter of 2.5 meters, light construction with elements of adaptive optics to compensate for atmospheric disturbances, a wave front sensor (shift interferometer), CCD matrices and the like.

The special gear is able to transmit images with a resolution at the ground in the visible spectrum of 0.08—0.1 meters in a strip of 2.8 x 2.8 km or 0.5—1.0 meters in a strip of 90 x 120 km, and about 0.6—0.8 meters in the infrared band in a strip of 2.8 x 2.8 km. By operating in the infrared wavelengths, it can distinguish cut leaf cover used as camouflage from living vegetation and determine the status of objects under surveillance.

The Advanced KH-11 satellite has the capability to detect the whole inventory of military hardware and armaments of various countries with high probability, and to track their rearming or upgrading.

A second Advanced KH-11 satellite was placed in orbit in February 1990 by the Atlantis spacecraft. It quickly became disabled, however. The CIA is planning to bring the number of such satellites in orbit to three, which would make it possible to accomplish the program of photo reconnaissance of the globe to the full extent.

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